Recurrent erosion of the cornea

NICHOLAS BROWN AND ANTHONY BRON
From the Institute of Ophthalmology, Judd Street, London

In previous studies of superficial corneal disorders (Bron and Brown, 1971) and of superficial lines of the cornea (Brown and Bron, 1976), we were impressed by the frequency of recurrent erosion of the cornea. In this study we have set out to examine patients presenting with recurrent erosion of the cornea to establish the type and incidence of the superficial corneal disorders, and to compare this incidence with that in a control group of subjects. Some experience of management of these patients is also reported.

Material and methods

MATERIAL

Patients presenting at the Casualty Department at Moorfields Eye Hospital with suspected recurrent erosion of the cornea were referred by the casualty officers and examined by one of us. The patient was admitted to the study if the diagnostic criteria were satisfied. These criteria were:

1. A history of initial trauma or abrasion followed by a recurrence of pain with healing, followed by a clinical recurrence at the time of presentation and associated at some time with the clinical signs of recurrent erosion.

2. A typical clinical history of at least two attacks suggestive of recurrent erosion (pain on waking or being awakened, difficulty in opening the eye lid, watering, light sensitivity), without a history of trauma but associated with clinical signs of recurrent erosion at some time.

For each group, the clinical signs of recurrent erosion could include not only frank epithelial loss, but also focal epithelial oedema, epithelial bulla formation, and epithelial cyst formation in varying combinations. In this way, 80 patients were admitted to the study with ages ranging from 24 to 73 years.

The control group consisted of 200 patients aged between 20 and 85 years, who had attended clinics at Moorfields but were not complaining of any symptoms referrable to the cornea, and had no history of corneal disease.

METHODS

A proforma was completed for each patient; this contained a full clinical history (including details of the

menstrual cycle and use of the contraceptive pill) and details of the examination of both eyes, including lids, tear films, corneae, and anterior chambers. The corneae were then re-examined after staining with fluorescein and with bengal rose. The corneal signs were recorded with the Zeiss photo slit lamp and with the macro camera (Brown, 1970) at 10 × magnification.

Each patient was re-examined at least once after complete healing of the erosion and both corneae were inspected for superficial dystrophies. The ocular tensions were measured at this time.

Despite the traditional name for the disorder, it is recognized that frank epithelial loss is not required to establish the diagnosis and that focal epithelial oedema or bulla formation with or without a breach in the epithelium, and/or the presence of epithelial cysts, are in keeping with the diagnosis when associated with the typical clinical history. The patients were classed as having either macroform or microform recurrent erosion by the criteria of Chandler (1945). Microform recurrent erosion was recognized by intraepithelial microcysts with a minor break in the epithelium (Fig. 1). In macroform recurrent erosion, a large area of epithelium was separated from the cornea (Fig. 2).

TREATMENT AND FOLLOW-UP

The initial treatment was decided by the Casualty Officer and consisted of either chloramphenicol drops or chloramphenicol ointment with hyoscine 0 5 per cent drops, and padding for the eye. Patients with large bags of loose epithelium were treated initially by debridement, the loose corneal epithelium being carefully removed at the slit lamp with a Bard Parker no. 15 blade, using centripetal strokes to avoid stripping off an unnecessarily large area of epithelium. The eye was then treated with drops or ointment and padded as above.

Eyes which failed to heal on medical treatment and produced redundant loose epithelium were debrided as above. In those eyes which still failed to heal on this regime, the debridement was repeated and followed by carbolization with 100 per cent phenol applied at the slit lamp with a small stick to the dried cornea. Care was taken to avoid carbolizing the pupillary area of the cornea, but the phenol was otherwise applied to as much of the affected area as possible.

Once healing was complete the patients were given sodium chloride 5 per cent ointment to apply each evening immediately before going to bed. This treatment was continued for from 3 to 18 months. Treatment of longer duration was given in patients who found that

they suffered relapses if they omitted to apply their ointment.

Treatment was eventually withdrawn from all patients still attending at 18 months and the relapse rate was compared with that while on treatment.

Results

AGE AND SEX DISTRIBUTION (Table I)

The age and sex distribution of the patients is shown in Table I, together with the incidence of macroform and microform recurrent erosion; it is common for both forms to occur in the same individual at different times (31 per cent of patients). Bilateral recurrent erosion is relatively uncommon (10 per cent of patients).

CAUSES OF INITIAL ABRASION (Table II)

The initial abrasion was frequently spontaneous (40 per cent of patients) and the patient was unable to remember any trauma having preceded it. Of the identifiable causes (Table II), the most common was a scratch by a finger nail, scratches from a baby's finger being particularly prevalent among women. Among men, the causes were also related to their occupations, and metallic objects such as screwdrivers were described as causative. Two cases were seen after the removal of corneal foreign bodies. In the two hereditary cases the patients had no recollection of trauma.

The microform type was the most common in the spontaneous cases (Table II), whereas macroform and combined macroform and microform erosions were more commonly of traumatic origin. In the eight bilateral cases trauma was reported
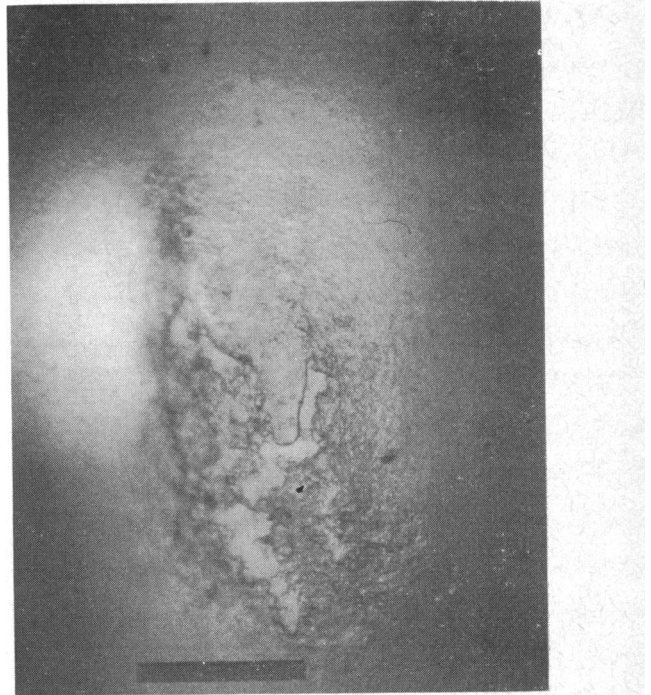

FIG. 1 *Microform recurrent erosion. Macrophotograph by retroillumination. Bar gauge 500 μm*

FIG. 2 *Macroform recurrent erosion. Stained with fluorescein to show intraepithelial microcysts. Bar gauge 1000 μm*

Table I *Age and sex distribution of 80 patients**

Age group (years)	No. of patients
21–30	13
31–40	22
41–50	22
51–60	18
61 +	5
At presentation (mean)	42
Percentage of women	48
men	52

Type of recurrent erosion	No.	Percentage
Macroform only	10	13
Microform only	45	56
Both types in same individual	25	31
Bilateral cases	8	10

*The youngest was 24, the eldest 73 years

Table II   *Causes of abrasion in 80 patients*

Abrasion	No.	Percentage
Spontaneous	32	40
Finger nail	18	22
Animal claw	3	4
Vegetable matter, for example, twig	12	15
Paper or card	7	9
Metallic object	5	6
Corneal foreign body	2	
Contact lens	1	

Relation of erosion type to trauma	No.	Percentage of traumatic cases	No.	Percentage of spontaneous cases
Macroform alone	8	10	2	3
Microform alone	20	25	25	31
Combined form	20	25	5	6

Table III   *Recurrences in 80 patients*

Time of recurrence	Percentage
At about the time of waking	76
Before waking (awakened by pain)	30
After waking	40
Difficulty in opening the eye	10
At other times of the day	24

Precipitation	
Nil	86
Eye rubbing	10
Barbiturates	2·5
Menstruation	1

by only three, and in two of these patients, the trauma had been to one eye only.

FREQUENCY AND PRECIPITATION OF RECURRENCE
(Table III)

The interval before the first recurrence after the initial abrasion varied from 2 days to 16 years, but it may be doubted whether this late recurrence was related to the initial abrasion after so long a time. The mean interval was 18 months, but this was weighted by a few very long durations, and 63 per cent occurred within 4 months.

Recurrences, both macro- and microform, occurred most commonly at around the time of waking (Table III). Some patients were able to

give a clear history of being awakened by the pain and, in others, the pain occurred after waking. An interesting symptom was difficulty in opening the lids; some patients needed to use their fingers to open their eye, and this was commonly followed immediately by a recurrence.

Precipitating factors were sought in the patient's history, but none was elicited in 86 per cent. Eye rubbing was admitted as a cause in 10 per cent and the use of barbiturates was implicated in 3 per cent. These patients experienced recurrences whenever they resumed taking barbiturates.

Altogether 23 menstruating women were studied, and in only one of these was there a clear history of recurrences related to the time of onset of each menstruation.

The general health of the patients appeared to be unrelated; the only finding which was in any way consistent was that of a history of atopy in 5 per cent. A family history suggesting dominant inheritance of recurrent erosion was obtained in two patients (3 per cent).

The frequency of recurrence was very variable, ranging from a minor recurrence each morning to major recurrences separated by many months. The frequency of recurrence varied between patients and at different periods in the same individual.

The recurrences lasted from 1 to 4 hours in the microform condition, and from 1 to 21 days in the macroform condition, which included two cases in which the healing was delayed by a secondary bacterial infection.

SYMPTOMS (Table IV)

The symptoms of recurrence (Table IV) are largely as anticipated. Blurring of vision varied from absent or minimal in many eyes with microform erosion to severe in macroform erosions.

SIGNS

When the eyes were examined at the time of active erosion, a small epithelial break (Fig. 1) was seen

Table IV   *Symptoms of recurrent erosion in 80 patients*

Symptoms	Percentage of patients
Pain	93
Severe pain	10
Blurring of vision	61
Watering	72
Photophobia	57
Redness	10

in microform erosion and a larger break, commonly with loose baggy epithelium around it, in macroform erosion (Fig. 2). The common site was central, just below the pupil. In both forms microcysts were present in the surrounding epithelium which usually stained well with fluorescein (Fig. 2). Some degree of epithelial and stromal oedema was common. The conjunctiva was injected and sometimes chemosed, especially in cases of macroform type. The anterior chamber was normally quiet, but sometimes showed a few cells in macroform cases.

In the healed state the eyelids and conjunctiva were unremarkable and an abnormal intraocular pressure was not found. Tear film thinning, demonstrated by the break-up of the fluorescein film, was found in 14 per cent. This was usually related to an area where the epithelium was uneven because of a superficial corneal dystrophy or epithelial cysts. However, the volume of tears did not appear to be abnormal and Schirmer's test gave results within the normal range.

SUPERFICIAL CORNEAL DYSTROPHIES
(Tables V, VI, and VII)

(The term superficial corneal dystrophy will be used for the group of changes occurring in the region of the corneal epithelium and defined below. Evidence for a genetic aetiology is currently small. See discussion.)

Superficial corneal dystrophies were a frequent finding (Table V) and commonly bilateral. The occurrence of the dystrophies was related to the age of the patient (Table VI). No patient seen in the present study was below the age of 30 years, but we have occasionally seen affected patients below this age. The frequency increases with age, reaching 78 per cent of patients in the 51 to 60 year age group.

The incidence of superficial corneal dystrophies in the patients is compared with that in the control group in Table IX. In the unilateral cases, the dystrophy was more frequently found in the unaffected eye than in the eye affected by recurrent corneal erosion, from which it may be deduced that the corneal erosion had been responsible for erasing clinical signs of the dystrophy.

The types of dystrophies which were found (Table V), were most commonly the various superficial corneal lines, which are listed separately in Table VII. Bleb dystrophy was also common, less commonly found was the more pronounced lacunar dystrophy of Bietti (1965) which we regard as synonymous with the 'map change' of Guerry (1965).

The individual superficial corneal lines have been described in detail (Brown and Bron, 1976). The most common type is the now familiar 'finger-

Table V *Incidence of superficial corneal dystrophies (including all types of lines)*

Dystrophy	Percentage*
All patients with superficial dystrophy or lines	59
Bilateral	66
In affected eye only	8
In unaffected eye	12
Fine superficial lines	46
Bleb dystrophy	28
Bietti's lacunar dystrophy (map dystrophy)	5

*Of 80 patients

Table VI *Age distribution of patients with superficial corneal dystrophies (excluding demarcation lines)*

Age group (years)	Patients		Percentage of age group
	No.	With dystrophy	
21–30	13	0	0
31–40	22	9	41
41–50	22	15	68
51–60	18	14	78
61+	5	3	60

Table VII *Incidence of fine superficial corneal lines*

Corneal lines	No.	Percentage*
Patients affected	37	46
Fingerprint lines	21	26
Demarcation lines	17	21
Superficial ring lines	1	—
Superficial corneal crazing	2	—
Mare's-tail lines	1	—
Tram lines	2	—
Bleb dystrophy and fingerprint lines in association	14	17

*Of 80 patients

print line' (Fig. 3) first described by Guerry (1950). These are fine refractile lines which are best seen by retroillumination. They are arranged in a near parallel whorl-like pattern, which gives them their resemblance to a fingerprint. Tear film thinning is commonly seen over the line. Two other fine lines which have the same retroillumination appearance as the fingerprint line, but differ in arrangement, are the superficial ring lines and superficial corneal crazing. The superficial ring lines form complete rings and the superficial

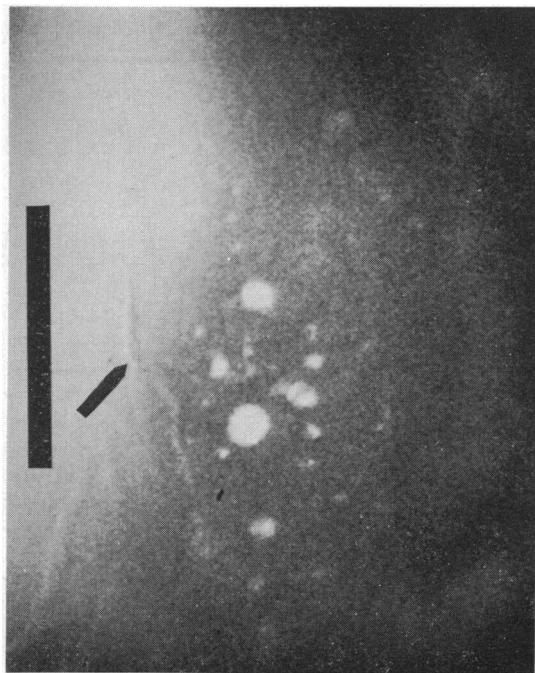FIG. 3   *Fingerprint lines. Seen by retroillumination of fundus. Bar gauge* 1000 μm

FIG. 4   *Cogan's epithelial microcysts with adjacent demarcation line* (arrowed). *Bar gauge* 500 μm
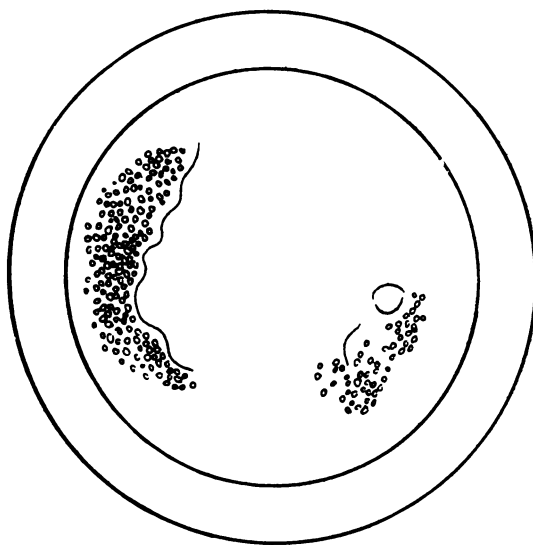

FIG. 5   *Demarcation lines marking limit of area of bleb dystrophy*

corneal crazing is found near the limbus and differs from the fingerprint line in having a branched pattern. Neither of these lines was common, but since each probably represents variants of the fingerprint line, its presence is considered to be related to recurrent erosion.

'Demarcation lines' (Fig. 4) have a superficial resemblance to fingerprint lines and are often found in the same eye where they separate areas affected by fingerprint lines, or by bleb dystrophy, from clear areas (Fig. 5). These lines often form complete rings of about 5 mm in diameter. They occur in eyes which have had recurrent erosion and are not seen in the fellow eye unless that too has been affected by erosion.

'Mare's-tail lines' (Fig. 6) are recognizably different from fingerprint lines, being seen best by focal illumination. These lines are bunched together in places and spread out in others; they show branching and crossing, which do not occur in fingerprint lines. They appear to be more superficial than the other lines and have a significant effect in thinning the tear film. Although only one patient is reported with mare's-tail lines in this series, we have seen them in other patients with recurrent erosion and in association with Bietti's lacunar dystrophy which is also related to recurrent erosion.

The remaining lines are 'tram lines', described by Brown and Bron (1976). These rare lines run a long, straight, nearly vertical course, and have refractile edges with the appearance of parallel tram lines. They were found in two patients in this series and in none of the controls. We are

FIG. 6 *Mare's-tail lines by focal illumination. Bar gauge* 500 μ*m*

unable to say whether their presence is related to recurrent erosion.

Dystrophic changes consisting of fine superficial blebs (Bron and Brown, 1971) were found in 28 per cent of patients. The blebs are seen only by retroillumination (Fig. 7) when they have the appearance of pebbled glass. They are subepithelial and do not affect the tear film. The blebs occurred in groups, sometimes covering large areas of the cornea, and were sometimes arranged in a characteristic hexagonal net pattern (Bron and Jones, 1969). Blebs were often absent from the region just below the pupil in eyes which had suffered recurrent erosion and in these eyes their limit was characteristically defined by a demarcation line (Fig. 5).

A less common finding (in 5 per cent of the patients and in none of the controls) was the superficial corneal dystrophy described by Bietti (1965) as lacunar dystrophy of Bowman's membrane (Fig. 8), in which clear lacunae up to 2 mm in diameter are seen on the surface of Bowman's membrane. The areas between the lacunae are opalescent and the edges of the lacunae are defined by a denser white line which may have a rolled appearance in focal illumination. The irregular pattern produced by the lacunae gives a map-like appearance, so that it is probably the same condition as that described by Guerry (1965) and thought by him to be a component of the epithelial

microcystic disorder described by Cogan, Donaldson, Kuwabara, and Marshall (1964). Numerous other workers have since observed these map-like changes (Wolter and Fralick, 1966; Levitt, 1971; Trobe and Laibson, 1972; Luxenberg, Friedland, and Holder, 1975).

MICROCYSTS (Table VIII)

Intraepithelial microcysts (Fig. 9) were a common finding in healed eyes, being present in 59 per cent of the patients (Table VIII), but they were seen in only 1·5 per cent of the controls (Table X). They occurred in conjunction with other recognizable dystrophies, but were the only recognizable corneal signs in 21 per cent. This left only 11 per cent of patients in whom no signs, either cysts or dystro-

Table VIII *Microcysts*

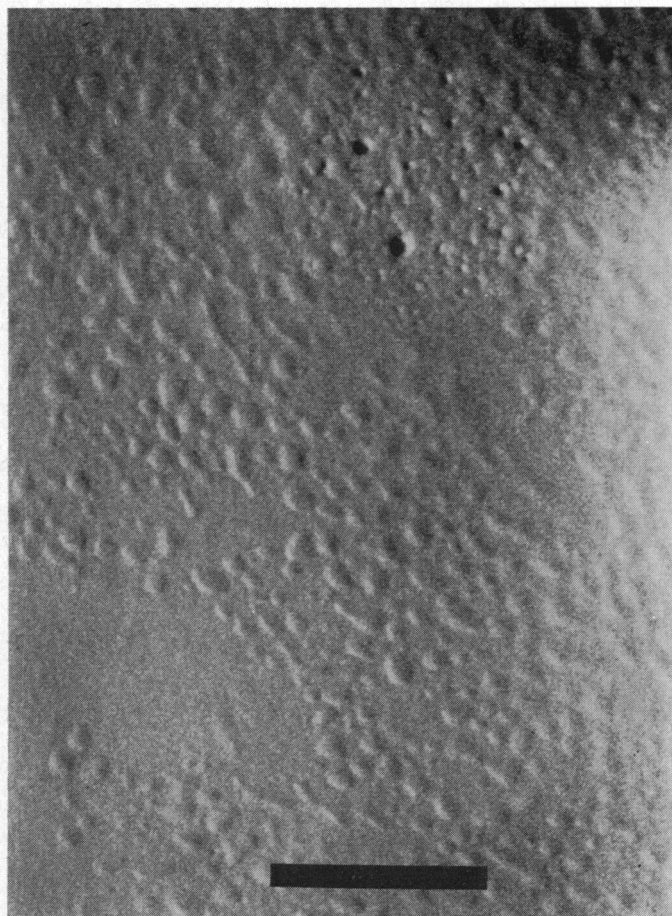| *Microcysts*	*Percentage*
Patients affected (total)	59
Erosion-affected eye only	49
Unaffected eye	24
Cogan's microcysts	6
Microcysts as only recognizable signs	21
Patients with neither dystrophy nor microcysts	11

FIG. 7 *Bleb dystrophy by retroillumination of fundus. Bar gauge* 500 μm

phies, were visible in the healed state. In most patients a retrospective diagnosis of recurrent erosion could be made with confidence when examining the patient in the healed state. Clinical symptoms, however, were always associated with clinical signs.

The microcysts were seen best by retroillumination, but sometimes contained opaque matter which made them visible by focal illumination. (This was most marked in those opaque white cysts having the appearance of those described by Cogan and others, 1964.) The microcysts, measured from the corneal macrophotographs, varied from 20 μm to 74 μm in diameter. The more superficial cysts, which sometimes showed a centrally umbilicated appearance, commonly stained with fluorescein, and those which did not stain showed as dark spots in the fluorescein, containing tear film. It was noticed that the cysts which were first seen after healing of an erosion showed the same distribution of light within them as that of the background when viewed by marginal retroillumination, which has been taken to imply a lower refractive index than that of the surrounding epithelium (Brown, 1971). After a month or more of treatment the cysts tended to be smaller and more discrete and in many eyes had disappeared. The remaining cysts sometimes changed their appearance as seen by retroillumination so that they now reversed the illumination compared with that of the background, implying a refractive index higher than that of the surrounding epithelium. The appearance was now like that of small oil droplets.

THE CONTROL GROUP (Table IX)

The findings in the controls are presented in Table IX. A low incidence of superficial dystrophies of the fingerprint line and bleb type and a few microcysts were found. In none of the controls was there any history of recurrent erosion, nor were there any symptoms referrable to the cornea.

Table IX *Incidence of superficial corneal dystrophies in* 200 *control eyes*

| Superficial corneal dystrophies	Percentage
Fingerprint lines	1·5
Microcysts	1·5
Blebs (including net patterns)	2·0

FOLLOW-UP AND RESPONSE TO TREATMENT (Table X).

Altogether 70 patients attended for follow-up from 1 to 48 months (mean 16 months).

Healing occurred after the recurrent erosion with which the patient had presented, in a few hours in minor microform and up to 3 weeks in severe macroform erosions. In two eyes, taking 3 weeks to heal, the healing had been delayed by corneal infiltration and oedema due to secondary bacterial infection. A healing time of 1 to 2 days was normal for the macroform erosions. The initial treatment given by the Casualty Officer was chloramphenicol drops or ointment and it did not appear to matter which of these was given. Debridement was performed as an initial treatment in 12 eyes which had large bags of loose epithelium. In each, this was followed by healing in 2 to 4 days (mean 3·1 days), and no cases of delayed

Table X *Response to prophylactic treatment for* 3–18 *months (mean 10 months)*

Treatment	No. of patients	Percentage*
NaCl 5 per cent ointment	60	60
Symptom-free	32	53
Improved	16	27
Not improved	2	3
Inadequate follow-up	5	8
Ointment rejected for stinging	5	8
Recurrences on treatment:		
Microform	8	14
Macroform	8	14
Effect of stopping treatment for 3 *months†*		
Treatment stopped in	32	
but 3 persisted against advice		
Therefore total in group	29	
Remaining symptom-free	5	17
Unchanged	5	17
Deteriorated	17	59
Recurrences off treatment:		
Microform	19	65
Macroform	3	10

*Of 60 patients   †Of 29 patients
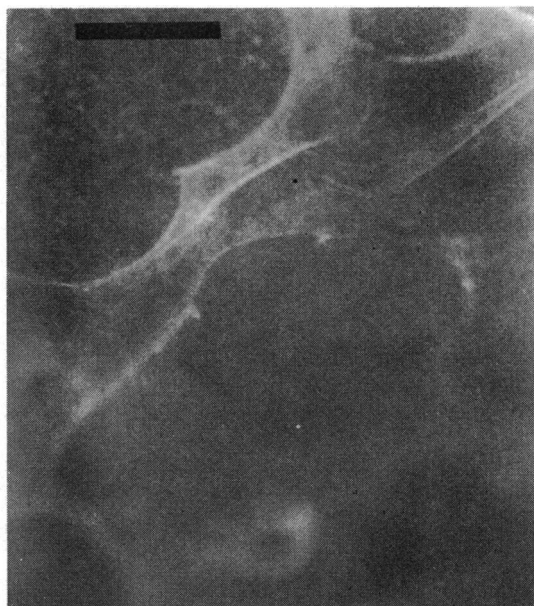
FIG. 8 *Bietti's lacunar dystrophy (map dystrophy). Bar gauge* 500 μm

FIG. 9 *Intraepithelial microcysts. Late stage of treatment showing reversal of marginal retroillumination. Bar gauge* 500 μm

healing occurred in these patients. Debridement was also carried out in four eyes showing lack of spontaneous healing with medical treatment during which a loose bag of epithelium developed. After

debridement, the epithelium was able to grow smoothly across the stroma. The incidence of recurrence after debridement did not differ from that in eyes which had received medical treatment alone. In one eye a deliberate attempt was made to scarify the surface of Bowman's membrane at debridement. No recurrence occurred in this eye, but the debridement left a faint superficial nebula.

Carbolization was performed after debridement in seven eyes and was followed by healing in 2 to 4 days. There was a single recurrence of a macroform erosion in two eyes and there were several recurrences of microform erosions in one eye which had been carbolized. Carbolization appears to be beneficial in reducing recurrence, but the number of eyes so treated was too small for the results to be significant.

Once healing was complete, 60 patients were given sodium chloride 5 per cent ointment to apply each evening immediately before going to bed. The result of this treatment was assessed after 3 months (Table X). Most patients were improved or even symptom free, but in some there were recurrences. The ointment was well tolerated by most patients, but 8 per cent found that it stung and stopped using it.

The effect of deliberately stopping the sodium chloride ointment was tested in 32 patients (Table X) after treatment for 3 to 18 months. The patients' symptoms tended to deteriorate, particularly with an increased incidence of recurrence of microform erosions. Thus three patients persisted in using the ointment against advice. It appeared that treatment could be more successfully withdrawn after a long period (12 months or more), and it was considered proper to withdraw treatment from all patients once they were able to remain comfortable without the ointment. Those in whom symptoms recurred resumed the use of the ointment.

Discussion

CLINICAL FEATURES

Recurrent erosion of the cornea has often been described, and a review of the early literature was well presented by Chandler (1945). The appearance of the active erosion has been fully documented and Chandler was able to divide the erosions, both symptomatically and by their appearance, into macroform and microform. This appears to be a useful classification, but it is now seen that the two different forms can occur in the same corneae at different times, and it is considered that there is no sharp distinction between the two disorders. Chandler found that macroform erosions were more commonly the result of trauma than microform erosions, which is confirmed by our observations.

The existence of bilateral cases was recognized by Chandler but has been considered rare, so that Flynn and Esterly (1966) thought it worthwhile to report a single case. The 10 per cent incidence of bilateral cases in our series is rather higher than that suggested in the literature.

An inherited form of recurrent erosion has been recognized since Franceschetti (1928) reported a family with a dominant inheritance. It would appear from our experience and that of other authors that a family history is uncommon. Two of our patients had a family history, but in neither case was there sufficient information to be certain of the pattern of inheritance.

The relationship of the time of the recurrence to the time of waking is interesting. We are in agreement with Chandler (1945) that the recurrence may occur before or after waking, although Szili (1900) maintained that patients always awoke first. In our patients who awakened first, difficulty in eyelid opening was commonly experienced, which suggests that there was an adhesion between the corneal epithelium and the eyelids. It is obscure why this should occur even if the epithelium is first lifted from the cornea. Drying of the tear film with incomplete lid closure in sleep has been suggested to account for this (Sturrock, 1975, personal communication). However, most authors take the opposite view and consider that increase in fluid in the cornea which lifts off the epithelium causes the recurrence. Thus Chandler (1945) and Theodore (1964) considered that an endothelial defect might be important in allowing fluid entry into the stroma; and Valle (1967) reported a family showing dominant inheritance of recurrent erosion in which one member had Fuchs's endothelial dystrophy which Valle considered to be significant. Cogan (1941) demonstrated the hypotonicity of tears during the night which he considered relevant in allowing fluid entry into the epithelium, and Thygeson (1959) considered that persistent epithelial oedema was a significant factor.

A rational approach to prophylaxis is therefore to use a lubricating agent at bedtime to prevent adhesion between the corneal epithelium and the lid, and an agent to produce corneal desiccation. The use of ointments as lubricants is traditionally accepted and methyl cellulose drops have been recommended by Guyard and Perdriel (1961) and by Theodore (1964). Theodore also recommended lowering intraocular pressure by acetazolamide. A combined lubricant and desiccating agent is convenient; Chandler (1945) and Thygeson (1959) used 10 per cent boric ointment, and Goldman, Dohlman, and Kravitz (1969), and Trobe and Laibson (1972), like ourselves, used 5 per cent sodium chloride ointment.

The existence of superficial corneal dystrophies in relation to recurrent erosion was probably

first recognized by Vogt (1930) who observed spots and fine glassy lines which appear in his illustration to be the same as those now called fingerprint lines. Brückner (1950) stated that no slit-lamp abnormality was to be seen in healed recurrent erosion, but he was able to demonstrate irregularity of the cornea with the Fisher reflectographic technique which is capable of demonstrating such fine abnormalities as the anterior corneal mosaic (Bron, 1968), also demonstrable by the proper use of retroillumination.

Several other authors, as reviewed by Chandler (1945), have described white or grey dots in corneae with healed recurrent erosions and these dots may now be described as microcysts. Microcysts may be relatively clear, with a low content of cellular debris, and variable in size; they are sometimes fused together and often take up fluorescein stain. The microcysts of Cogan's microcystic disorder are more often densely opaque and discrete; they fail to take up stain and may reach a large size (Bron and Tripathi, 1973). Although such cysts may occur together in the same cornea, their morphogenesis may be different. Like Cogan, Kuwabara, Donaldson, and Collins (1974), we believe that the special features of the Cogan type of cyst relate to their sequestration behind anomalous intraepithelial basement membrane sheets (Bron and Tripathi, in preparation). Cogan's microcystic dystrophy has in the past been regarded as benign and responsible at most for minor irritative symptoms (Cogan and others, 1964; Guerry, 1965; Levitt, 1971; Bron and Tripathi, 1973; Luxenberg and others, 1975). Attention has been drawn by Trobe and Laibson (1972) to the association of these cysts with map dystrophy (which we regard as identical to the lacunar dystrophy of Bietti (1965)) and with fingerprint lines and recurrent corneal erosion. Brodrick, Dark, and Peace (1974) confirmed the relationship between Cogan's microcystic dystrophy, fingerprint lines, and recurrent corneal erosion. In the present study cysts of the Cogan type and map-like dystrophy are found, but their incidence is low.

Proper attention has only recently been given to the relationship between the superficial dystrophies of the fingerprint line, bleb, and net type and recurrent corneal erosion; in fact Guerry (1950), in his original description of fingerprint lines, considered them to be of no pathological significance, but a relationship between fingerprint lines and recurrent erosion has been reported by Kaufman and Clower (1966), Bron and Brown (1971), Trobe and Laibson (1972), Brodrick and others (1974), and Brown and Bron (1976), and between bleb and net patterns and recurrent erosion (Bron and Brown, 1971).

It appears that the various superficial corneal disorders which are associated with recurrent corneal erosion are not discrete entities but represent a spectrum of visible signs with a common pathological background. Many of our patients showed several different forms of disorder in the same or fellow eye and this relationship has been commented upon previously; Guerry (1965) and Levitt (1971) reported the relationship between Cogan's microcystic and map-like changes, Bron and Brown (1971) reported the association of fingerprint lines and bleb and net patterns together, and their relationship with recurrent erosion, and Trobe and Laibson (1972) reported the relationship between Cogan's microcystic dystrophy, map-like dystrophy and fingerprint lines, and recurrent erosion.

Most corneal abrasions heal satisfactorily and are not followed by recurrent erosion. Jackson (1960) saw one recurrent erosion in 150 abrasions and Guyard and Perdriel (1961) saw no recurrences in 40 abrasions.

It appears that recurrent erosion follows in a cornea which is already abnormal. The high incidence of superficial corneal dystrophies in our patients (Table V) as compared to controls (Table IX) supports this suggestion. That the superficial dystrophies are the precursor of the erosion and not the result of it, is demonstrated by their higher incidence and greater extent in the asymptomatic eye (Table V). The recurrent erosion appears to erase the dystrophic changes so that they may be absent or only minimally present in the healed cornea. The dystrophic change has also been removed by deliberate debridement as observed for fingerprint lines by Guerry (1950), and for Cogan's microcystic dystrophy by Wolter and Fralick (1966) and Cogan and others (1964, 1974). This would occur if the defective basement membrane (see below) was also shed with the lost epithelium.

In our earlier study (Bron and Brown, 1971), 40 patients ranging in age from 39 to 41 years were found to exhibit superficial corneal changes of the fingerprint, bleb, and net pattern and the changes were bilateral in 73 per cent, suggesting a dystrophic or degenerative aetiology. Symptoms of recurrent erosion were seen in 38 per cent of patients. In the present study of 80 patients with recurrent erosion syndrome, the incidence of superficial corneal changes (fingerprints, blebs, nets, and maps) was 59 per cent compared to 3·5 per cent in the control group (lines and blebs). (Cysts are excluded from the comparison because they may at times be a non-specific expression of the presence of epithelial oedema. Data are available in Tables VIII and IX.) This strongly supports the contention that the superficial corneal changes under discussion are responsible for defective epithelial adherence and

render patients vulnerable to recurrent erosion.

It appears that the patients studied by us in the past (Bron and Brown, 1971) and in the present study are substantially the same group as that studied by Trobe and Laibson (1972). Differences relate to the low incidence of map change and Cogan's cyst change in our studies and to the absence of net and bleb changes in the series studied by Trobe and Laibson. These differences may relate in part to matters of definition, since we attempted to distinguish on biomicroscopic grounds cysts of the Cogan type from other microcysts associated with recurrent erosion (Bron and Tripathi, 1973), and in part to methods of examination. It is important to emphasize the need for careful examination of the cornea by retroillumination, using first the iris and then the red reflex of the fundus with the pupil dilated, in order not to miss the finest dystrophic changes.

It seems likely that a common histopathological factor in all these disorders is the anomalous production of basement membrane material and other connective tissue sheets both within and sometimes deep to the corneal epithelium. This has been observed both in the absence of clinical map-like changes (Cogan and others, 1964, 1974), and in their presence (Guerry, 1965; King and Geeraets, 1972; Tripathi and Bron, 1973; Rodrigues, Fine, Laibson, and Zimmerman, 1974; Fogle, Kenyon, Stark, and Green, 1975; Dark, Brodrick, and Peace, 1973), and Brodrick and others (1974), demonstrated the presence of a fibrillo-granular material with intra- and subepithelial extension in a patient with fingerprint lines. The histopathology of bleb and net patterns is not yet known.

The relevance of basement membrane abnormalities to recurrent erosion has been clarified in recent years. Khoudadoust, Silverstein, Kenyon, and Dowling (1968) experimentally showed the importance of the basement membrane and of the hemidesmosomes of the basal epithelium to epithelial adherence. Poor epithelial adherence is implied by the erosion itself and can be demonstrated by manipulating a contact lens on the healed cornea of these patients (Lowe, 1964, 1970). A defective basement membrane was demonstrated in traumatic recurrent erosion by Goldman and others (1969), and in spontaneous recurrent erosion by Tripathi and Bron (1972), who also noted an absence of hemidesmosomes in relation to affected basal cells. Kenyon (1969) suggested that deficiencies in the formation of basement membrane, hemidesmosomes, and attachment fibrils account for the erosive events encountered in Reis-Bückler's dystrophy, Cogan's microcystic dystrophy, and non-traumatic recurrent erosion (Fogle and others, 1975). Presumably a similar mechanism is involved in metaherpetic keratitis (Kaufman, 1964).

It would appear that the biomicroscopic appearance of fingerprint lines, of map changes, and probably of the net and bleb patterns relate to the location, amounts, and optical properties of anomalous basement membrane and other connective tissue material situated in the affected epithelium, and that recurrent erosion episodes are related partly to the presence of subepithelial connective tissue sheets and to a disturbance of the epithelial adhesion mechanism.

RESPONSE TO TREATMENT

In the initial treatment it would appear to make no difference whether the antibiotic is given as drops or an ointment, which accords with the experimental work of Hanna, Fraunfelder, Cable, and Hardberger (1973). The complication of entrapment of ointment beneath the epithelium (Fraunfelder, Hanna, Cable, and Hardberger, 1973) was not seen. However, it was noticed that the refractile appearance of microcysts as seen on retroillumination could change so that they came to resemble oil droplets.

Simple debridement, without scarification or carbolization of the surface of Bowman's membrane, appears to be beneficial in assisting healing of a macroform erosion, but not in preventing recurrence. This is not surprising since the problem appears to be one of epithelial adherence rather than of epithelial resurfacing. Some form of physical or chemical injury to the cornea has commonly been recommended. Chemical cautery has frequently been advocated (Chandler, 1945), and our own experience with carbolization in a small number of patients would appear to support this. However, carbolization does leave a faint superficial nebula, and is best avoided except for highly intractable recurrent erosions. Debridement with deliberate scarification of Bowman's membrane has been recommended (Kaufman and Clower, 1966; Trobe and Laibson, 1972) and is probably useful in preventing recurrence, as in the only case so treated by us. However, this also leaves a superficial scarring.

Successful prophylactic treatment with hypertonic agents has been described by Chandler (1945), Thygeson (1959), Goldman and others (1969), and Trobe and Laibson (1972). The hypertonic agent which we used, sodium chloride ointment 5 per cent, was shown to be effective in dehydrating the human cornea by Luxenberg and Green (1971) who obtained a reduction of 20 per cent in the thickness of oedematous corneae. The sodium chloride ointment was well tolerated by the patients and appears to have been effective in preventing recurrence, as witnessed by the increased incidence of recurrence once it had been

withdrawn (Table IX). The reduction in size and the increase in refractility of the microcysts with their eventual disappearance in some eyes suggests desiccation.

Patients could be successfully withdrawn from treatment, particularly after long periods, so that it would appear that the use of the ointment is curative in the long run, or that recurrent erosion is a self-limiting disorder. The ointment is a logical choice (as discussed above), but we cannot be certain at present whether the lubricant or desiccant properties are the more important. A future trial against a simple lubricant ointment should be informative.

Conclusions

Recurrent erosions occur in corneae with poor adhesion between the epithelium and Bowman's membrane, and defective basement membrane complexes are implicated. The defect is commonly present in the cornea before the initial trauma as witnessed by the high incidence of superficial corneal dystrophies.

The examination of the cornea in the healed state commonly reveals a superficial dystrophy, or the presence of microcysts. The diagnosis of recurrent erosion can thus be made on slit-lamp examination in most healed cases and less reliance need be placed on the verbal history alone.

Fluid, collecting in or beneath the epithelium during the night, with resultant lifting of the epithelium and adherence of the epithelium to the tarsal conjunctiva are two possible factors leading to recurrence.

In the initial treatment it does not matter whether drops or ointment are used. Debridement of loose epithelium assists healing and resolves pain sooner, but does nothing to prevent recurrences. Recurrence is best prevented with a lubricant and desiccant substance (sodium chloride 5 per cent ointment) applied at bedtime. This can be discontinued after several months once the patient remains symptom free on withdrawal. No precise period for prophylactic treatment can be given and it must be adjusted for the individual patient. In eyes which continue to be severely affected by recurrence, in spite of prophylactic treatment, epithelial adhesion can be improved by carbolization or debridement with scarification, but these procedures may cause scarring.

Summary

Altogether, 80 patients aged between 24 and 73 years with recurrent erosion of the cornea have been studied and compared with a control group of 200. The patients' erosions were divisible into macroform and microform types. The macroform occurred in 10 per cent, the microform in 56 per cent, and both types in the same patients in 31 per cent. The macroform was more commonly related to trauma than the microform. However, many (40 per cent) were spontaneous in origin. The most common cause of the initial trauma was a finger nail.

The recurrences occurred at around the time of waking, either just before or just after. Difficulty in opening the eye occurred in 10 per cent. There was little evidence of precipitating factors, but eye rubbing was admitted by 10 per cent and barbiturates were implicated in 3 per cent.

The corneae were examined in the healed state, when a high incidence (59 per cent) were found to have superficial corneal dystrophies of the fingerprint lines, bleb, and Bietti's lacunar (map-like) types. These are considered individually, particular attention being paid to the distinctions between the various types of line resembling the fingerprint line. Epithelial microcysts were also a common finding (59 per cent) and were sometimes of the Cogan type. In only 11 per cent of patients were there no corneal signs in the healed state. The need for careful examination of the cornea by retro-illumination, using both the iris and the fundus, is stressed. The control group, in contrast, showed a very low incidence of dystrophies and cysts.

Treatment was given initially with either drops or ointment and no differences in healing were found. Debridement was performed in 12 eyes as an initial treatment and also in four eyes which were not healing on medical treatment. Debridement assisted healing, but did not prevent recurrence. One eye was treated with debridement and scarification and seven with carbolization. These procedures appeared to reduce the recurrence rate.

Sodium chloride ointment 5 per cent was found useful as a prophylactic taken at bedtime, and the recurrence rate increased when it was withdrawn.

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